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Earth Sciences Consultants, Inc.
One Triangle Drive
Export
Pennsylvania 15632
412/733-3000

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Project No. 9672-01

Peter J. Kalis, Esquire
Kirkpatrick & Lockhart
1500 Oliver Building
Pittsburgh, PA 15222

Summary Report
Geophysical Survey of
Impoundment No. 3
Fansteel Metals
Muskogee, Oklahoma

Dear Mr. Kalis:

Earth Sciences Consultants, Inc. (ESC) has completed geophysical surveying activities in the vicinity of Impoundment No. 3 at the Fansteel Metals (Fansteel) plant in Muskogee, Oklahoma to delineate a potential groundwater contaminant plume associated with the July 18, 1989 impoundment failure. Because wastewater spilled from the impoundment reportedly had a low pH and high metals concentration, groundwater conductivity values should be significantly higher in areas impacted by the spilled wastewater. Therefore, to delineate anomalous conductivity areas (which are assumed to correlate with potential groundwater contamination), an electromagnetic terrain conductivity (EM) survey was conducted over the area displayed in Figure 1.

The EM unit used for this survey was a Geonics Limited EM34-3 ground conductivity meter. The unit consists of receiving and transmitting coils with associated hardware to generate and measure electromagnetic fields. The coils are always oriented such that they are coplanar, but their axes can be either vertical or horizontal. With the coil axes oriented horizontally, the effective depth of investigation (skin depth) is approximately 0.75 times the coil separation. With the coil axes vertical, the skin depth is approximately 1.5 times the coil separation. In the latter configuration, the instrument is less sensitive to near-surface layers but more sensitive to lateral conductivity variations which may produce spurious readings.

This unit measures the electrical conductivity of the ground by inducing eddy currents then measuring the secondary magnetic field produced. The inducing field is produced by the transmitter coil that is separated by a fixed horizontal distance from the receiving coil. The instrument measures ground conductivity in units of millisiemens per meter with the measured value being an apparent conductivity of the earth volume between the ground surface and an effective penetration depth determined by the dimensions and configuration of the instrument. The value is a weighted average such that the conductivities of deep layers of soil and water contribute less to the measured value than do the conductivities of shallow layers.

Data Acquisition and Reduction

To provide reference points for delineating the extent of anomalous conductivity plumes and to provide unbiased measurement locations, a 50-foot center-to-center hand-surveyed grid was established over the area shown in Figure 1. Because of cultural interferences (man-made interference such as buried pipelines or fences) and data requirement needs, the grid was modified during survey operations. Figure 2 presents actual measurement locations obtained during the course of data acquisition. To conform with standard geophysical practice, the grid was oriented in a north-south direction. To assess whether potentially contaminated groundwater has migrated off site, additional measurements were obtained off the surveyed grid to the north and east of the impoundment. These are shown in Figure 2 as all measurement locations east of Line 925 on the X-axis. (Data locations are referred by their X-axis position and then their Y-axis position with a comma separating the two.)

Two sets of EM data were collected during the course of the study. At each measurement location, readings were taken with the coils in the horizontal and vertical dipole configurations using a 10-meter fixed coil separation. This procedure yielded two distinct sets of data representing skin depths of approximately 25 and 50 feet, respectively. Because groundwater ranged between 15 to 25 feet below ground surface, these skin depths were sufficient to investigate groundwater conductivities.

After data acquisition was completed, it was necessary to reduce the data into a format conducive to interpretation. Because ground conductivity patterns are more easily interpreted on maps in a line format, the data are displayed on isopleth maps and isometric enhancements to delineate conductivity variations. To handle the large data set efficiently, a computer program utilizing the minimum curvature method of gridding was used to generate the isopleth maps and isometric enhancements necessary to interpret the data.

Results

The data collected during this investigation were interpreted to delineate anomalous conductive plumes that could indicate the presence of groundwater contamination. In addition, the data were evaluated to assess the impact of

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cultural interferences on data quality and to interpret the validated data in terms of waste distributions and possible contaminant sources.

Figure 3 is an isopleth map of EM data with an effective depth of penetration of 25 feet. Figure 4 displays the same data but as an isometric enhancement. Inspection of these two figures reveals a large magnitude linear conductivity anomaly running due north from Position 250,300 to approximately 250,600. Because of the linear nature, very high amplitude main body, and sharp transverse cutoff, the anomaly is considered a cultural interference (possibly a buried powerline or pipeline). The remainder of the data displayed in these figures appears to be free of cultural interferences.

Conductivity measurements adjacent to the impoundment display elevated readings as would be expected considering the size of the spill. However, further inspection of the data displays subtle decreases in conductivity values with increasing distance from the impoundment. Approximately 200 feet north of the impoundment, conductivity values drop to background levels. This correlates with the existing groundwater chemistry data that indicate contaminant migration to the north is not occurring. Because the large amplitude cultural interference to the west of the impoundment would mask conductivity anomalies generated by potential groundwater contamination, an evaluation of groundwater impacts in this direction cannot be made. Measurements taken in the vicinity of Outfall No. 3 indicate conductivity values drop to background levels within approximately 180 feet northeast of the impoundment. (Outfall No. 3 is located along the northeastern fence line in the downgradient direction.) Therefore, based on the geophysical data to the east and northeast, it appears that groundwater contamination has not migrated beyond the fence line in this direction. However, because of significant elevation changes in this direction, accurate conductivity measurements could not be obtained. Therefore, the geophysical data may not be representative of true groundwater conditions in this direction.

Figure 5 is an isopleth map of EM data with an effective depth of penetration of 50 feet. Figure 6 displays the same data but in an isometric enhancement. In general, there is a good correlation of conductivity trends between these data and the shallower data. However, the linear trend between Positions 250,200 and 250,600 is more pronounced and the data values display greater variation in amplitude. This is typical with vertical dipole data because the EM34 sensor is more sensitive to lateral conductivity variations and is prone to be influenced by nearby metallic objects.

In summary, both the vertical and horizontal dipole EM data coupled with available chemistry data provide evidence that near-surface groundwater has been impacted by wastewater released from Impoundment No. 3 during the July 18, 1989 impoundment failure. The geophysical data and groundwater chemistry data provide evidence that groundwater 200 feet to the north of the impoundment has not been impacted by the spill and that contaminant migration beyond 200 feet in this direction is not occurring. Groundwater impacts to the west, east, and south of the impoundment cannot be determined because of the cultural interferences. Should you have any questions, please contact us.

Sincerely,

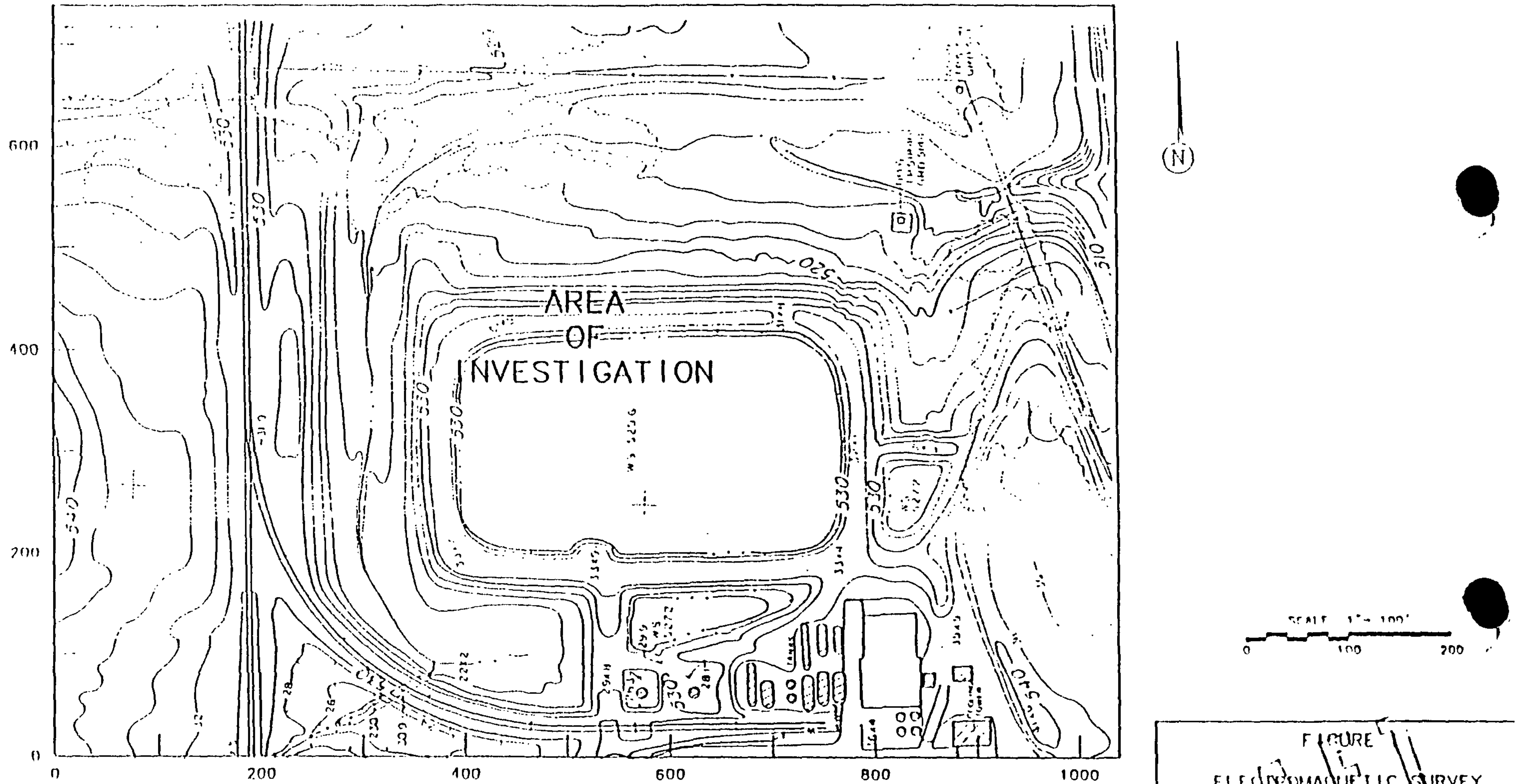
David R. Perry
Project Hydrogeologist

Scott C. Blauvelt
Director Geosciences

DRP/SCB:kms

Enclosures

cc: M. Mocniak
T. S. Carlile, Jr.



FIGURE

ELECTROMAGNETIC SURVEY
AREA OF INVESTIGATION

PREPARED FOR
FANSTEEL METALS
MUSKOGEE, OKLAHOMA

DRAWING NUMBER
9672-B13

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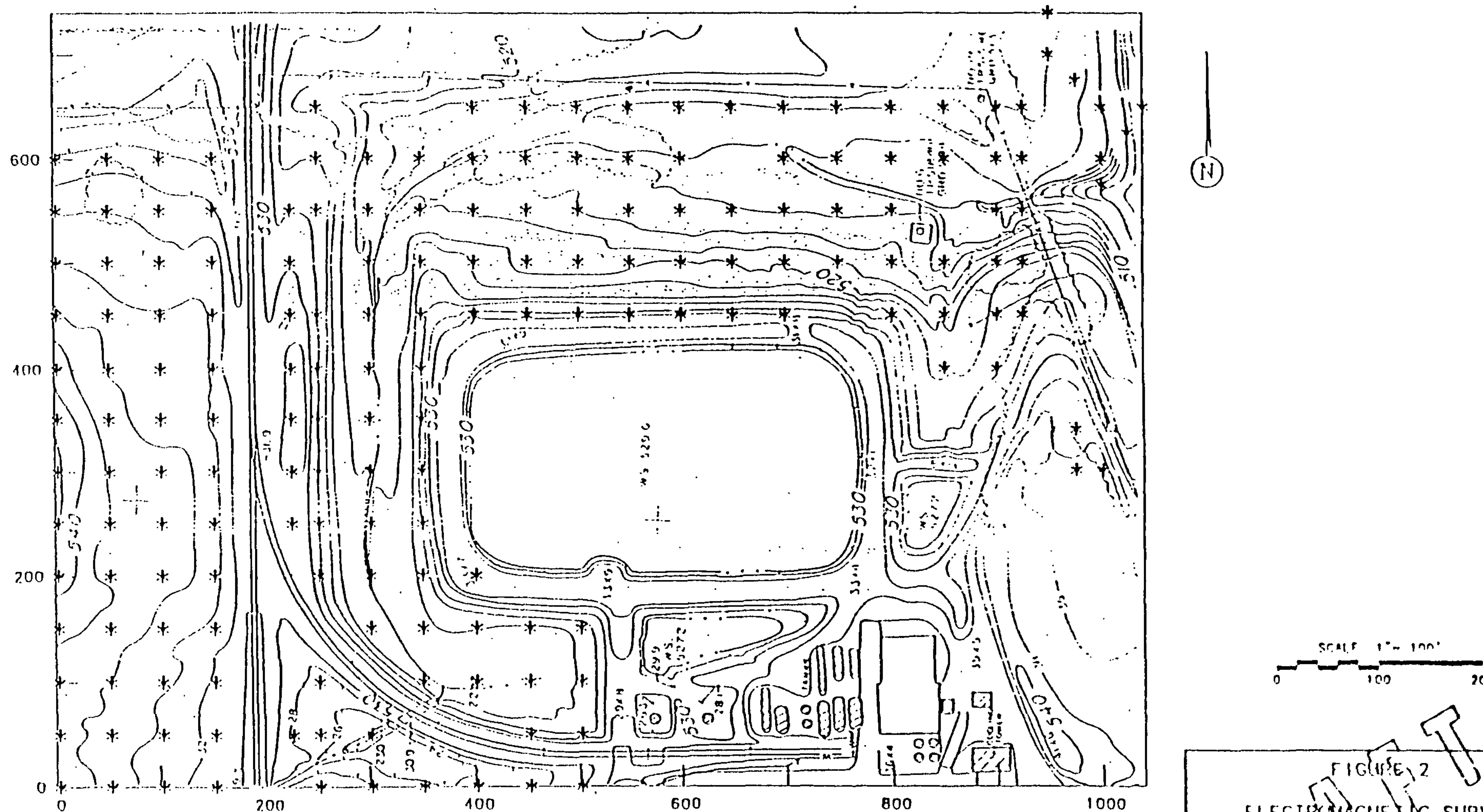

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FIGURE 2

ELECTROMAGNETIC SURVEY MEASUREMENT LOCATIONS

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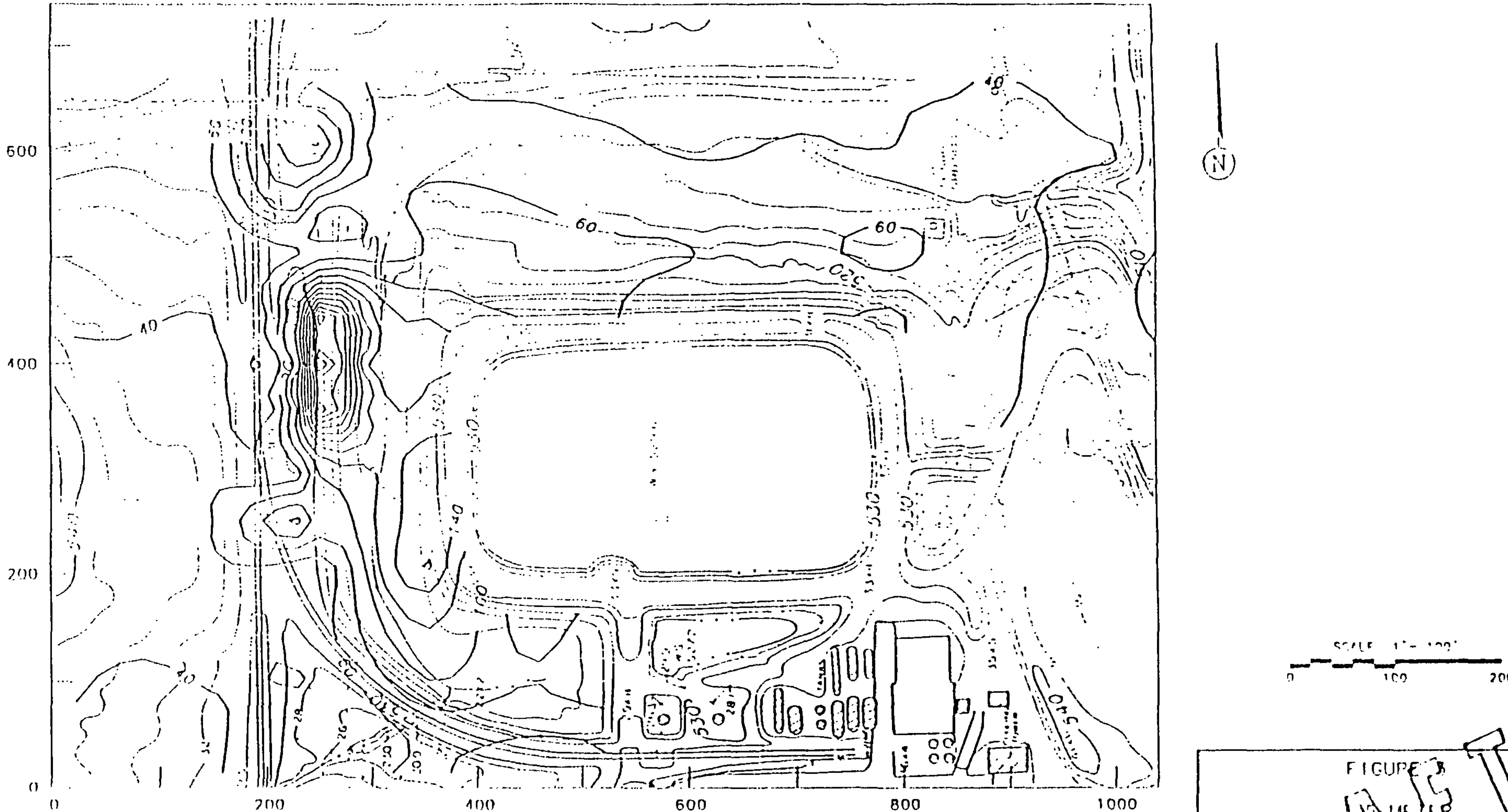

NOTE
CONTOUR INTERVAL = 20 MILLISIEMENS/METER

FIGURE 3

METER
DEPTH OF INVESTIGATION
CONDUCTIVITY ISOPLETH MAP

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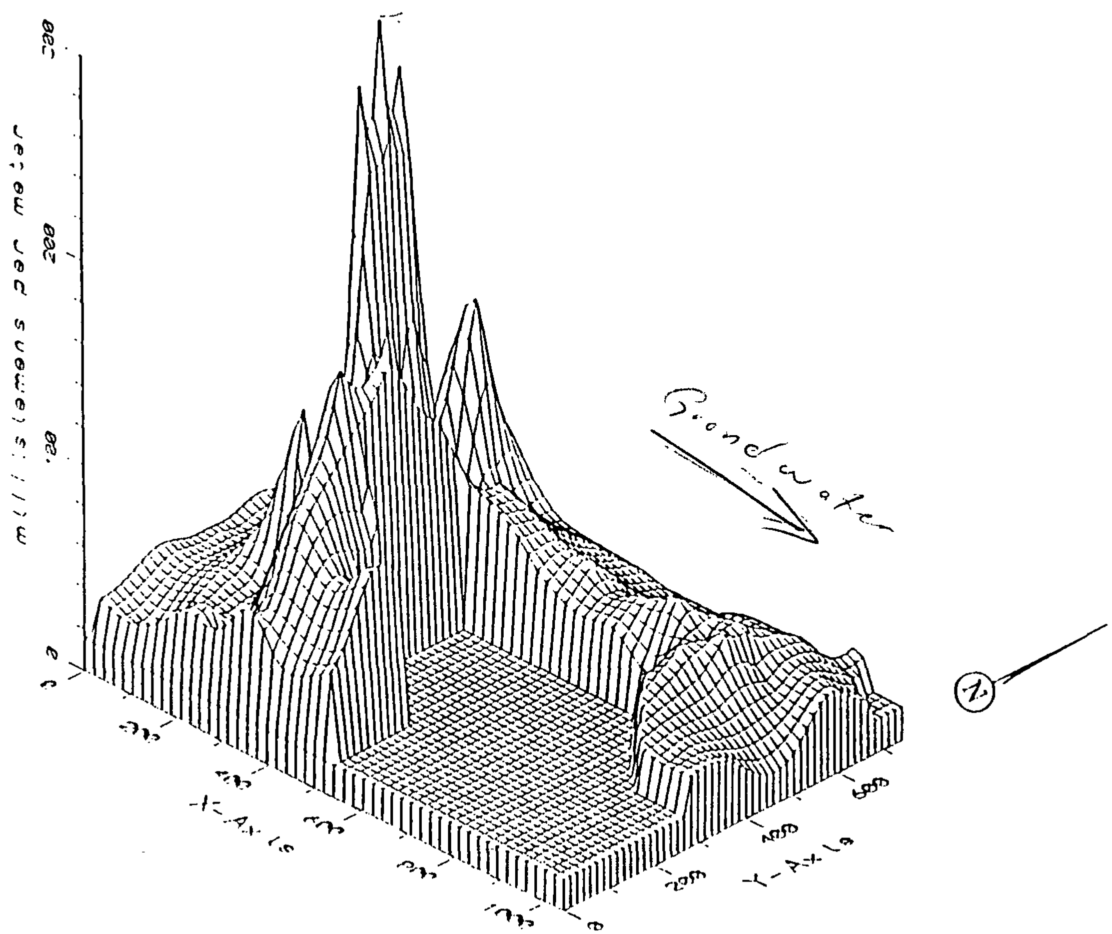

SCALE 1" = 200'

0 200 400

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FIGURE 4

5 METER
DEPTH OF INVESTIGATION
ISOMETRIC ENHANCEMENT

PREPARED FOR

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MUSKOGEE, OKLAHOMA

APPROVED
CHECKED

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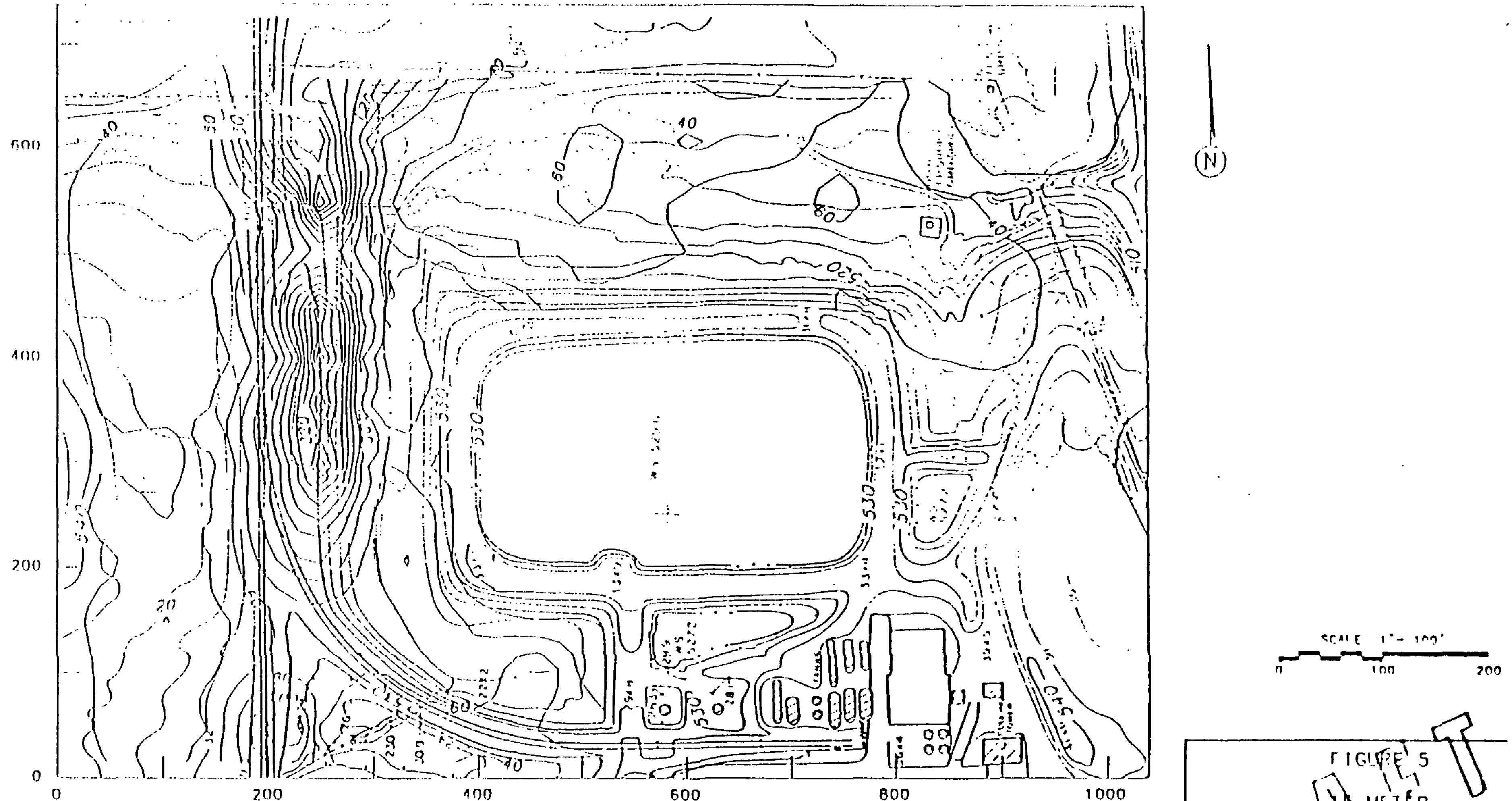

NOTE
CONTOUR INTERVAL = 20 MILLISIEMENS/METER

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FIGURE 5

15-METER
DEPTH OF INVESTIGATION
CONDUCTIVITY ISOPLETH MAP

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MUSKOGEE, OKLAHOMA

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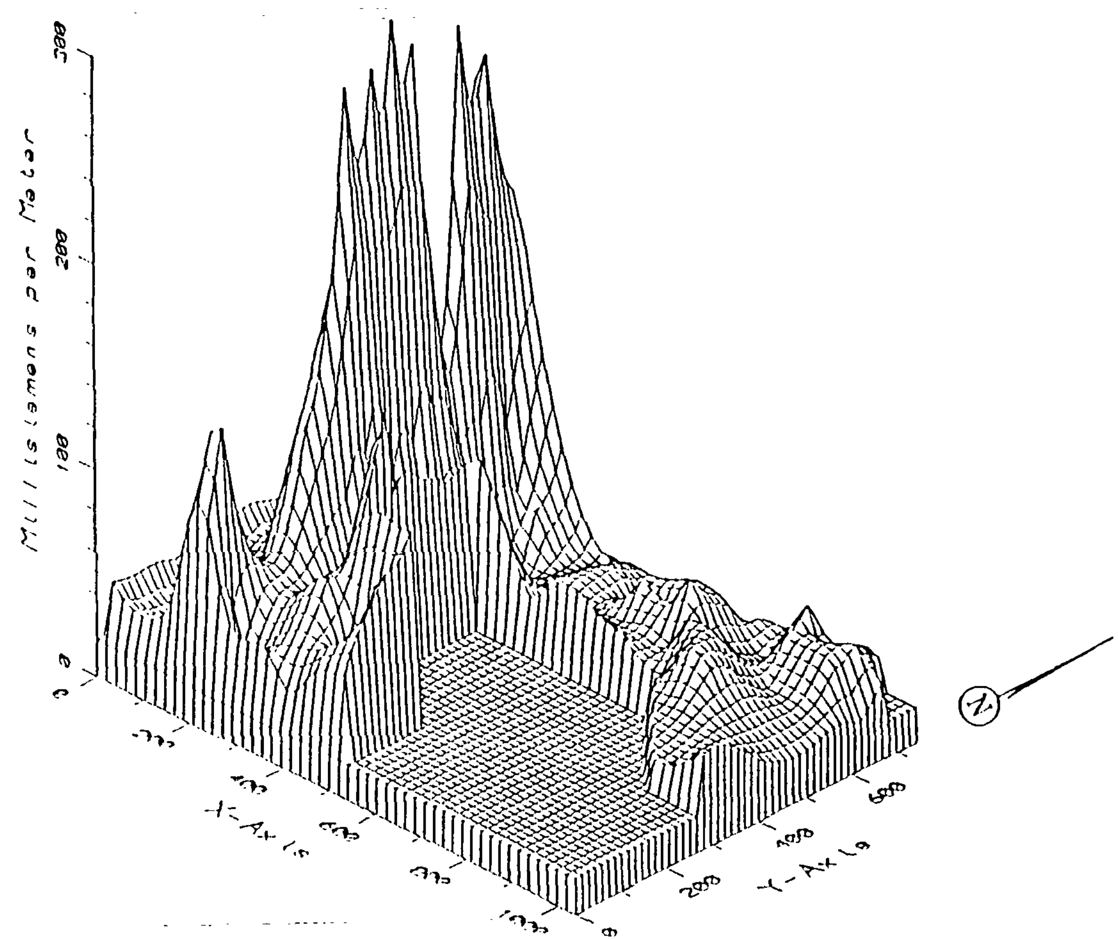

SCALE 1" = 200'

0 200 400

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FIGURE 6

15 METER
DEPTH OF INVESTIGATION
ISOMETRIC ENHANCEMENT

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MUSKOGEE, OKLAHOMA

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